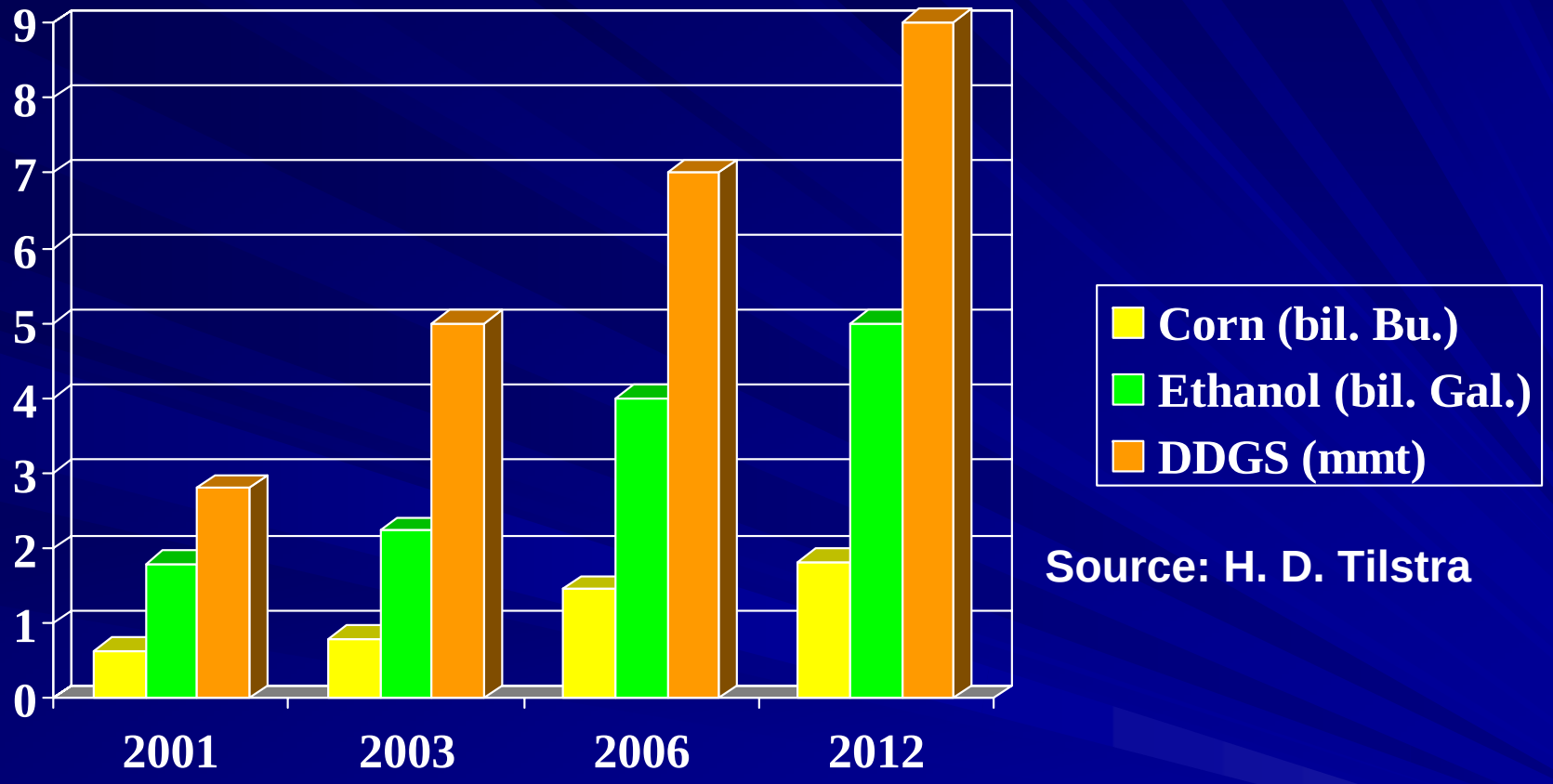
Feed Manufacturing with DDGS

Kim Koch, Ph.D.
Northern Crops Institute

United States Ethanol Outlook

Values are Underestimated



Source: H. D. Tilstra

Dry-Milling Average Yield Per Bushel of Corn

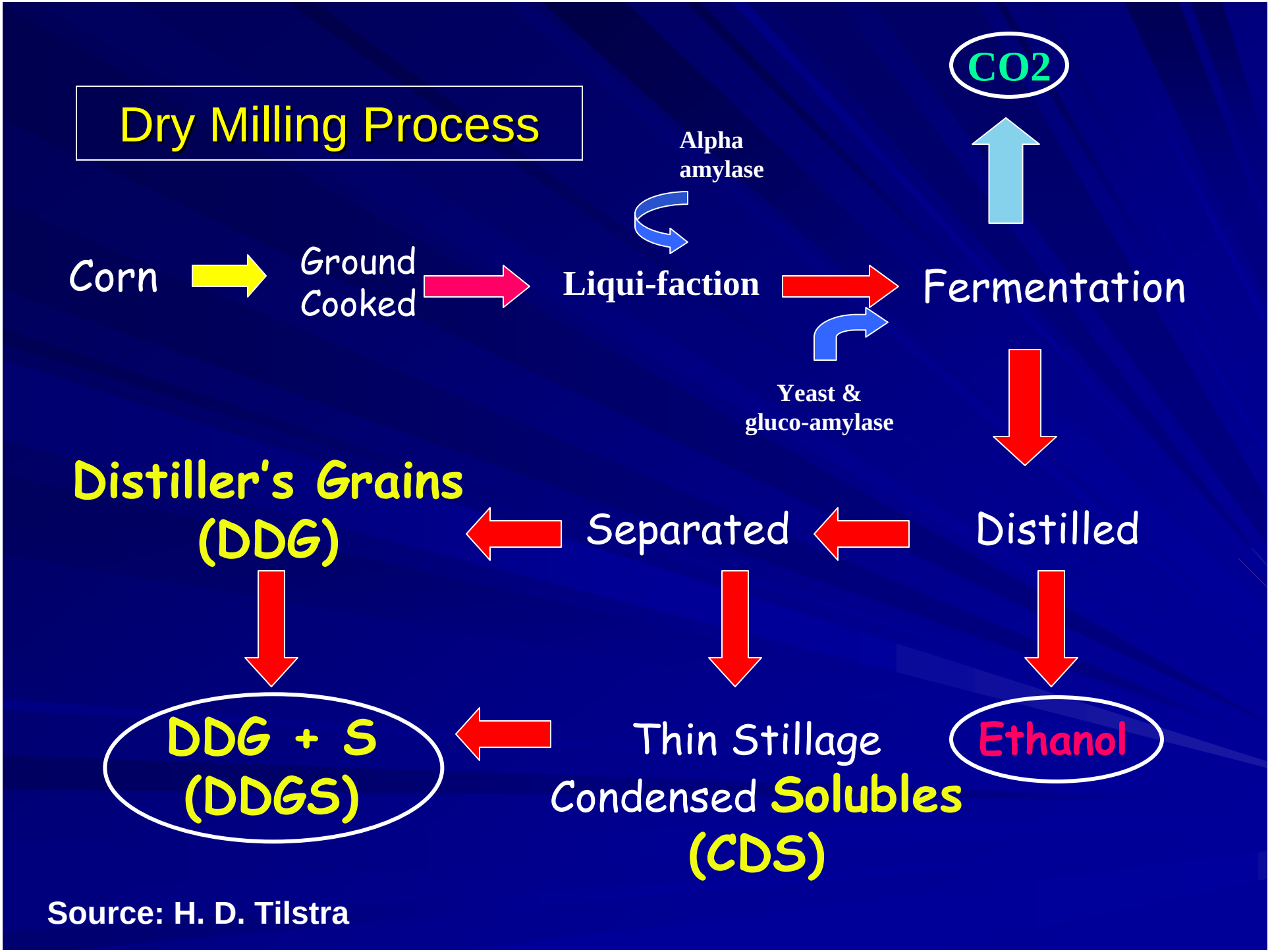
Ethanol 2.7 gal. (10.2 liters); CO_2 18 lbs. (8.2 kg); DDGS 18 lbs. (8.2 kg)

- **Every gallon of ethanol produced = 6.67 lbs. (3.02 kg) of DDGS**
- **Current estimate is ?? million gallons = ??? mmt of DDGS**

What is DDGS?

- DDGS is a by-product of fuel ethanol production
  - **Typically from a dry-grind facility**
    - **Whole kernel processing**
- Nutrient content of DDGS depends on the grain source
  - **Corn DDGS – Midwest US**
  - **Wheat DDGS – Canada**
  - **Sorghum (milo) DDGS – Great Plains US**
  - **Barley DDGS – Canada/US**
- Other by-products
  - **DDGS from beverage alcohol – whiskey distilleries (dry grind)**
  - **Corn gluten feed – high fructose corn syrup, starch (wet mill)**
  - **Corn gluten meal – high fructose corn syrup, starch (wet mill)**
  - **Brewer's grains (wet/dry) – beer production (dry grind)**
- Nutrient profile of by-products from dry-mill, wet-mill, and beverage alcohol production is different

from Shurson, 2006


Dry Milling Process
CO2
Alpha amylase
Corn
Ground Cooked
Liqui-faction
Fermentation
Yeast & gluco-amylase
Distiller's Grains (DDG)
Separated
Distilled
DDG + S (DDGS)
Thin Stillage
Condensed Solubles (CDS)
Ethanol
Source: H. D. Tilstra

Dry-Grind Ethanol By-Products used by Livestock (Poultry)

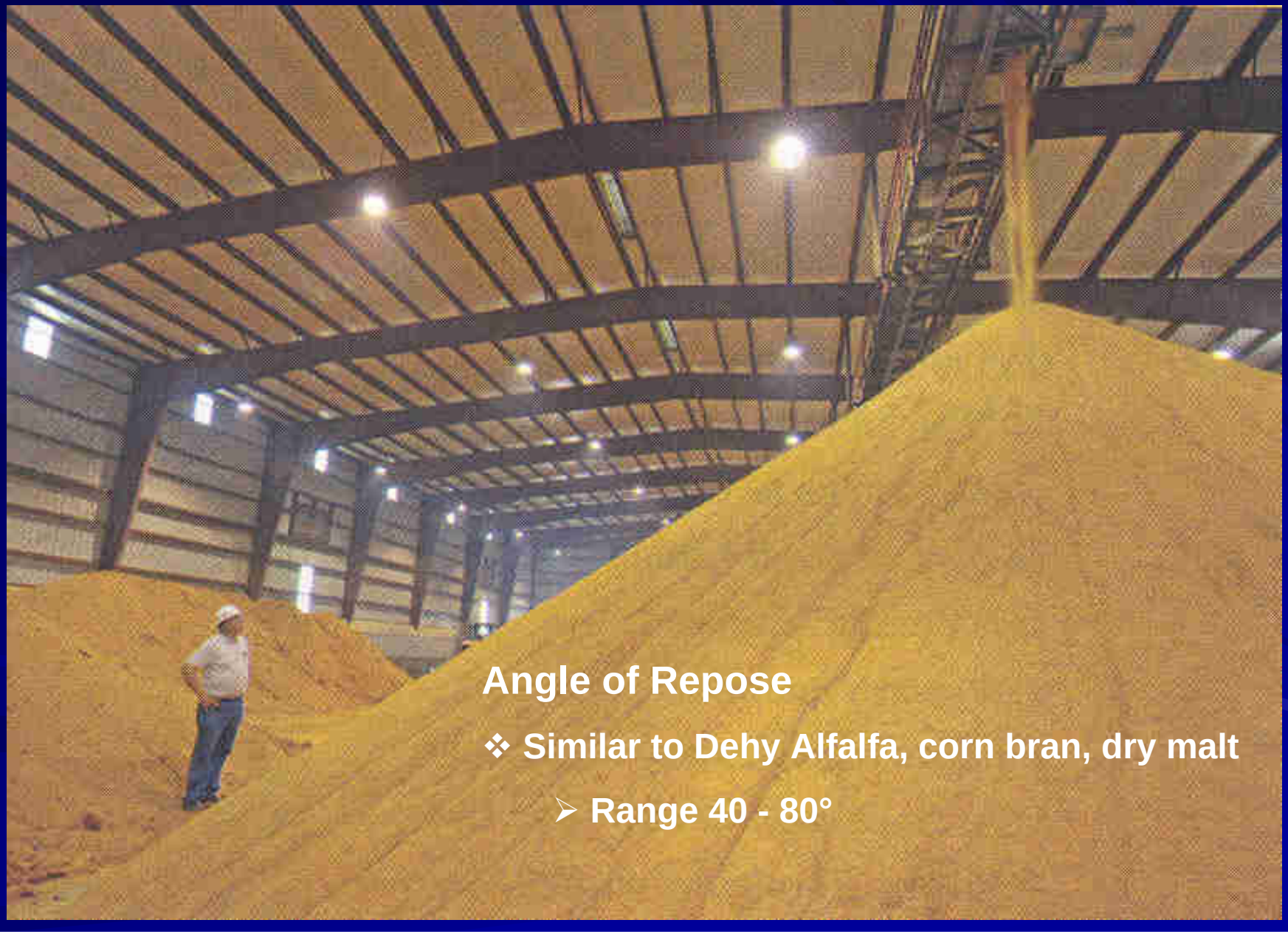
- Wet distiller's grains
  - Fed primarily to beef, some dairy – Total Mixed Rations (TMRs)
- Dry distiller's grains (DDG)
  - Fed to beef and dairy – concentrates
- Wet distiller's grains with solubles (WDGS)
  - Fed to beef and dairy - TMRs
- Dried distiller's grains with solubles (DDGS)
  - Fed to dairy, swine, poultry, some beef – concentrates, complete feeds
- Modified wet cake (blend of wet and dry distiller's grains)
  - Fed primarily to beef, some dairy - TMRs
- Condensed distiller's solubles (CDS)
  - Fed to beef and dairy – TMRs
  - Ontario, Canada – swine liquid feeding system

from Shurson, 2006

DDGS Physical Characteristics

- Knott, Shurson and Goihl
  - Bulk Density
    - **Average = 45.9 kg/hl**
    - **Range 39.6 – 50.6 kg/hl**
  - Particle Size
    - **Average = 1,282 microns**
    - **Range 612 – 2,125 microns**
- Koch
  - Bulk Density
    - **Average = 48.4 kg/hl**
    - **Range 45.4 – 51.3 kg/hl**
  - Particle Size
    - **Average = 588 microns**
    - **Range 387 – 810 microns**

DDGS Physical Characteristics



Angle of Repose

- **Similar to Dehy Alfalfa, corn bran, dry malt**
  - **Range 40 - 80°**

DDGS Nutrient Characteristics

- Knott, Shurson and Goihl
  - Protein
    - **Average = 26.6**
    - **Range 24.54 – 28.4**
  - Fat
    - **Average = 10.0**
    - **Range 9.2 – 11.6**
  - Fiber
    - **Average = 6.9**
    - **Range 5.8 – 9.1**
- Koch
  - Protein
    - **Average = 27.6**
    - **Range 26.3 – 29.9**
  - Fat
    - **Average = 9.2**
    - **Range 8.1 – 10.2**
  - Fiber
    - **Average = 10.0**
    - **Range 5.5 – 16.0**

DDGS - Handling

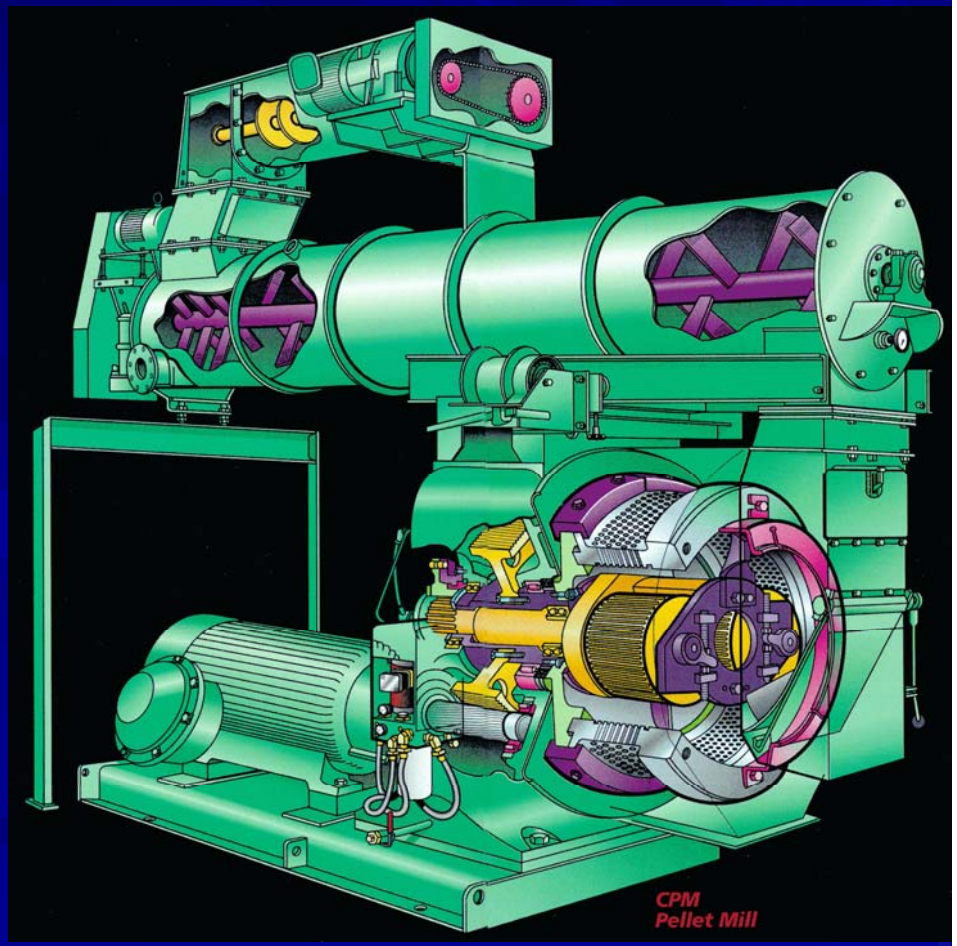
- DDGS sets up in rail cars, trucks, containers, barges, (ocean-going vessels ?)
  - DDGS will set up more than once
    - **Will set up in silos and bins**
- Currently no flow agents have been found that completely correct the flow/handling problems associated with DDGS
  - Some may reduce unloading time
    - from 10 hrs to 5 hrs
- Some reports that “New” generation products improve handling characteristics

Practical issues with DDGS Used in Feed Manufacturing

- Product is Inconsistent – Unpredictable
  - Nutrient content
    - **Protein, Fat, Fiber, Moisture, etc.**
  - Nutrient digestibility
    - **esp. for lysine**
  - Physical Characteristics
    - **Bulk density, Particle size, Angle of Repose**
  - Logistics
    - **Multiple producers, brokers/consolidators, shippers**
  - Handling
    - **Flowability – flat storage is recommended**
- Availability
  - **Price**
- Mycotoxins
- High fiber limits its maximum inclusion level in poultry feed

DDGS and Pellet Production

- Decreased pellet quality
  - Depends on physical and nutrient characteristics of DDGS
    - **Fat, fiber, protein, moisture**
    - **Particle size, density**
  - Depends on ingredients
    - **Some are complementary**
  - Depends on pellet mill operation
    - **Conditioning time and temp**
    - **Die speed – slow down**
    - **Die specifications**
      - **Performance ratio**



DDGS and Pellet Production

- Koch
  - DDGS and Durum wheat midds
    - Increasing DDGS from 0 – 50%
      - **A 35% increase in amperage**
      - **A 41% increase in kilowatts**
      - **A 15.5% increase in kwh/mt**
      - **A 3% decrease in pellet quality measured as Pellet Durability Index (PDI)**
      - **An 11% decrease in pellet bulk density**
    - Increased energy use
      - **Added $0.11/mt to production costs**
    - Decreased pellet quality
      - **may cause reduced feed efficiencies**
      - **Increased transportation costs**

DDGS and Pellet Production

- Koch
  - DDGS and barley malt sprouts
    - Increasing DDGS from 0 – 30%
      - **A 40% decrease in amperage**
      - **A 40% decrease in kilowatts**
      - **A 47% decrease in kwh/mt**
      - **A 3% decrease in pellet quality measured as Pellet Durability Index (PDI)**
      - **A 10% decrease in pellet bulk density**
    - Decreased energy use
      - **saved $0.65/mt in production costs**
    - Decreased pellet quality
      - **may cause reduced feed efficiencies**
      - **Increased transportation costs**

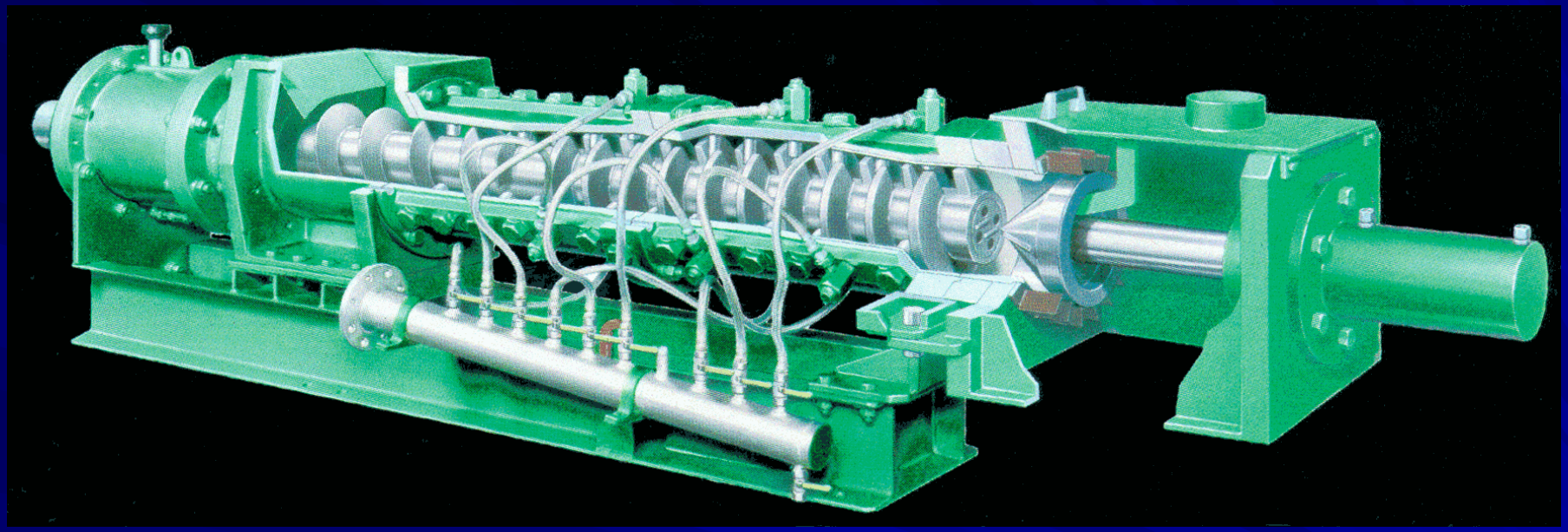
DDGS and Pellet Production

- Koch
  - DDGS, Durum wheat midds and dry peas
    - DDGS at 20%, peas at 20%, midds at 60%
      - **Compared to 100% midds**
        - **40% increase in amps**
        - **42% increase in kw**
        - **13% increase in kwh/mt**
        - **0.5% increase in PDI**
      - **Compared to 60% midds, 40%DDGS**
        - **21% increase in amps**
        - **18% increase in kw**
        - **7.6% increase in kwh/mt**
        - **2% increase in PDI**

DDGS and Pellet Production

- Koch
  - DDGS, Durum wheat midds and dry peas
    - DDGS at 30%, peas at 20%, midds at 50%
      - **Compared to 100% midds**
        - **43% increase in amps**
        - **46% increase in kw**
        - **15% increase in kwh/mt**
        - **0.8% decrease in PDI**
      - **Compared to 50% midds, 50%DDGS**
        - **6% increase in amps**
        - **3% increase in kw**
        - **2% increase in PDI**
        - **1% decrease in kwh/mt**

DDGS and High Shear Conditioning



- Alteration of protein and fiber
  - **Operate at greater temperature, pressure and moisture than pellet mills**
    - **Low bulk density materials (DDGS) do not absorb moisture readily in pellet mill conditioner**
    - **High natural protein materials (DDGS) becoming “gummy” when moisture addition exceeds 4% and plasticize at temperatures in excess of 63° C**

Things to Remember

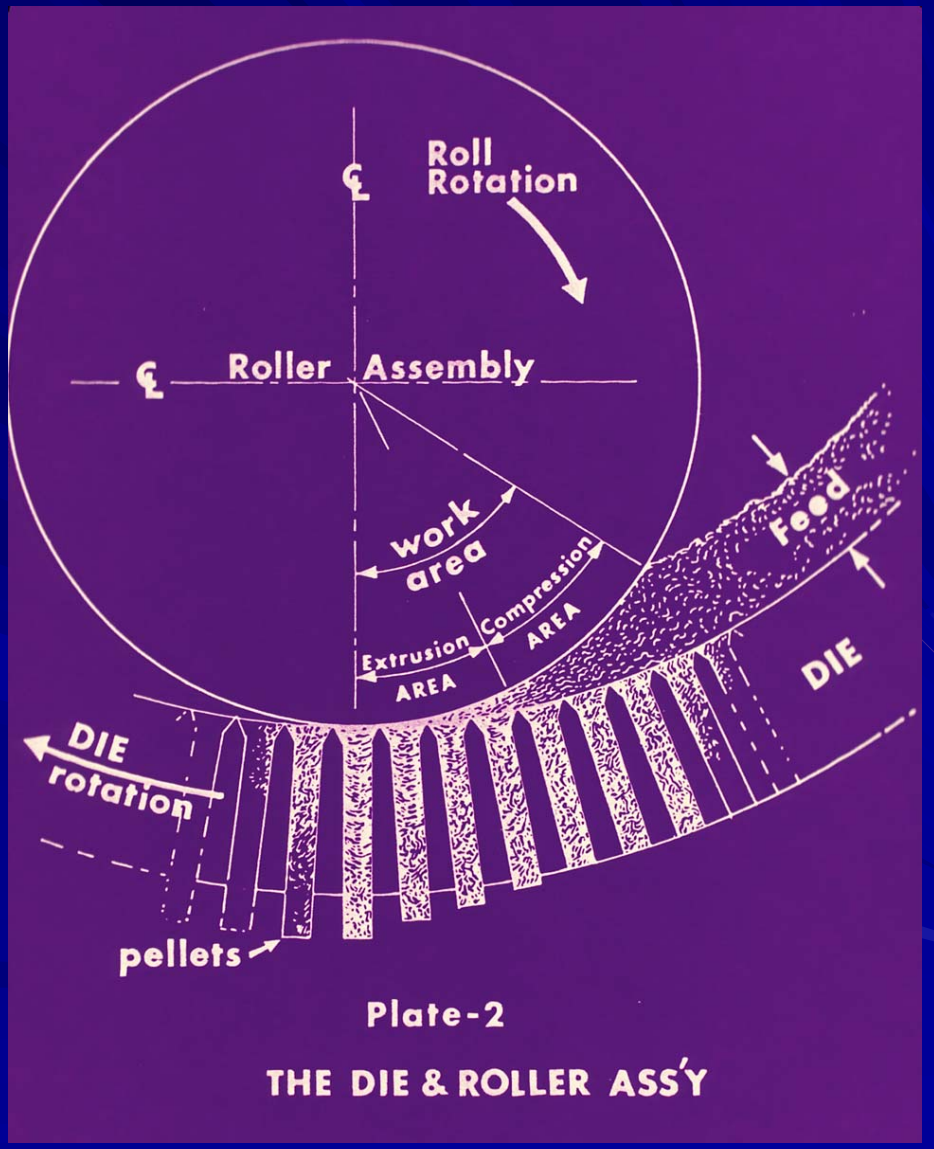
- DDGS is a by-product of fuel ethanol production
  - Typically corn – but can be from other cereals
- Physical characteristics of DDGS are dissimilar
  - Bulk density, particle size and angle of repose are not uniform
- Nutrient content of DDGS depends on the grain source
  - Changes nutrient value

- **The above alter performance of pellet mills and other feed manufacturing equipment**

Thank You

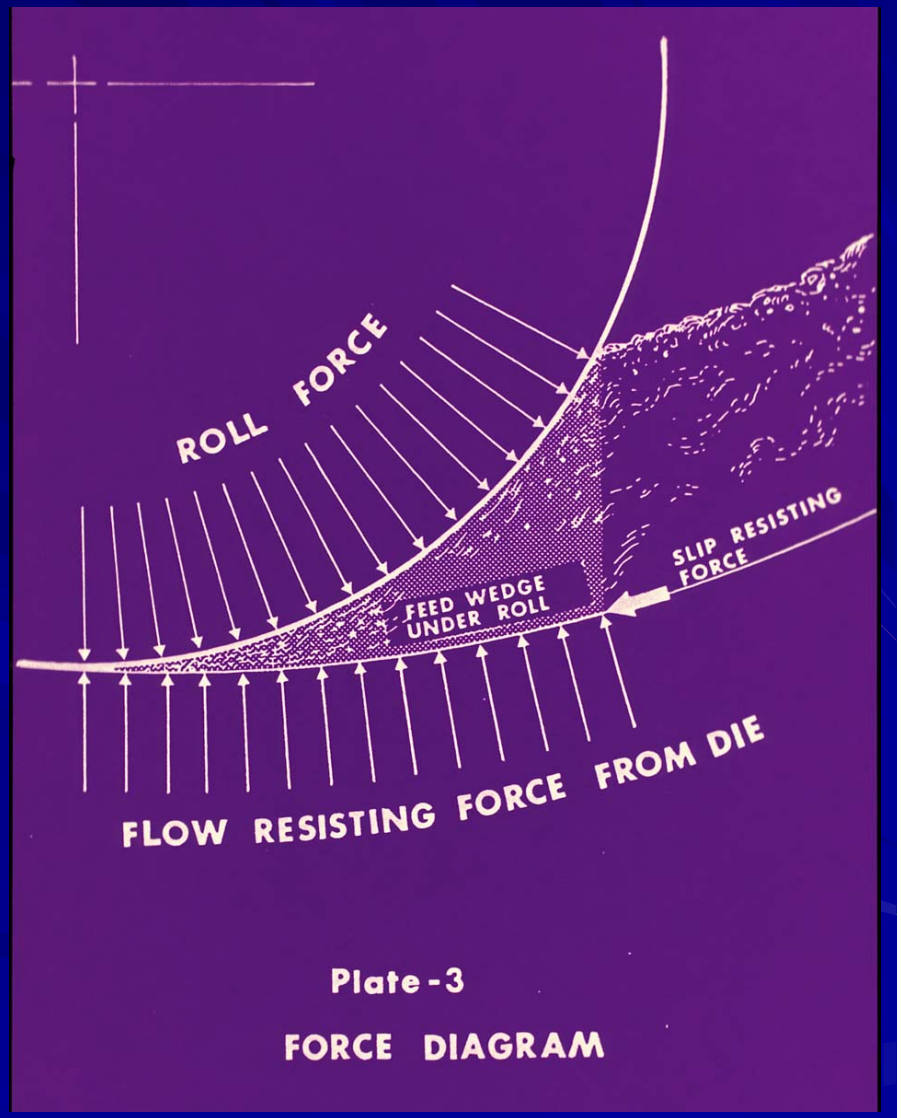
Fundamentals of pellet production

- Die – Roller interaction
  - Feed on the die face must be compressed and extruded through the die holes during successive rotations
    - **Excess moisture (> 17%) in the feed will cause the roll to slip**
      - **Resist compression**
    - **Materials high in natural protein and low bulk density are difficult to pellet**
      - **DDGS become “gummy” with the addition of moisture > 4%**
      - **DDGS do not absorb steam well**



Fundamentals of pellet production

- In order to make pellets must have all forces balanced
  - Moisture, fat, fiber and protein have important role in pellet production
    - If slip-resisting force greater than roll force material will not compress
      - **Caused by moisture, fat, protein**
    - If flow resisting force greater than roll force material will not extrude
      - **Caused by fiber, particle size**



Fundamentals of pellet production

- Feed material is compressed into the die hole and extruded through the effective length.
  - Factors that determine Pellet Quality
    - Performance ratio (d/L)
    - Compression ratio (D/d)